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(71) Applicant (*for all designated States except US*): NORSK HYDRO ASA [NO/NO]; N-0240 Oslo (NO).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): INGELS, Rune [NO/NO]; Bergsv. 103, N-3960 Stathelle (NO). VAN-MARCKE, Luc [BE/BE]; Gravin D'Alcantaralaan 43, B-9971 Lembeke (BE). NEVEJANS, Rudy [BE/BE]; Haverreep 17, B-9960 Assenede (BE). ELDERSON, Roeland [NL/NL]; Van Gistellelaan 37, NL-4571 EG Axel (NL). KLONTEIG, Jon, Gunstein [NO/NO]; Enggravtunet 24D, N-3711 Skien (NO).

(74) Agent: JOHNSEN, Venche, Høines; Norsk Hydro ASA, N-0240 Oslo (NO).

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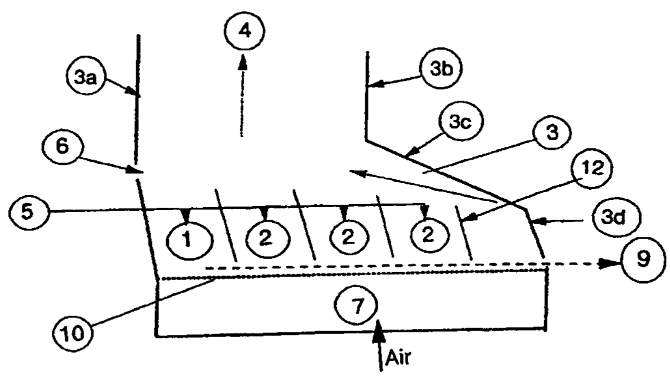
(54) Title: A METHOD AND A DEVICE FOR PROCESSING A SOLUTION, MELT, SUSPENSION, EMULSION, SLURRY OR SOLIDS INTO GRANULES



Classifying Fluid Bed, Open Design, Side View

(57) Abstract: The present invention relates to a classifying fluid bed granulator, comprising a granulation chamber with a fluidizing air chamber (7) with a bed floor (10), a ceiling (3c), an end wall (3d), a feed inlet (5), a seed inlet (6), an outlet (4) defined by walls (3a, 3b) for air, and an outlet (9) for produced granules. The granulation chamber is divided into an agglomeration and seed control section (1) and a granulation and classification section (2) where said section (2) is divided into two or more consecutive compartments having an asymmetric design. Section (2) may contain tilted baffle plates (12). Furthermore, the present invention relates to a method for fluid bed granulation of a feed being a solution, slurry, melt, emulsion, suspension or solids into granules of a desired classified size. Inlet seed particles are given a controlled size in an agglomeration and seed section ahead of being granulated with the feed in a granulation and classification section. The classification of the granules is performed in asymmetric compartments in the granulation and classification section.

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"A method and a device for processing a solution, melt, suspension, emulsion, slurry or solids into granules"

The present invention relates to a method and a device for processing a solution, melt, suspension, emulsion, slurry or solids into granules of a classified size.

Fluid bed granulation or fluidized bed granulation is a technique used in particulation of melts, solutions, slurries, emulsions, suspensions or solids for instance in the fertiliser- and food industry.

A fluid bed granulation process is combining several sciences and technologies. To operate a fluid bed granulation plant properly, requires knowledge of melt and solution chemistry, crystallisation properties, total mass- and energy balance, mass- and energy transport, particle- and granulometry balance, fluid dynamics and fluidization technology.

To design and operate these plants is difficult due to the fact that the mass balance, energy balance and granulometry balance must be set correctly to give the right performance with regard to capacity and quality. Each of the balances can not be set independently as most of the control parameters available to operators and designers are affecting all three balances. The balances expressed as a limited and simplified set of equations will also have several solutions, where the optimum or best solution is depending on the chemical and physical properties of the product system, product quality and cost of utilities and other input factors.

Different salt systems have different solubilities and different heat of crystallisation. In fluid bed design these differences give a variety of design parameters and settings for air flow and temperature, recycle flow and temperature, melt temperature and concentration. The most important factor for the fluid bed granulation process is the control of the liquid phase together with the over all energy balance and granulometry balance through the particle growth and the production of seed particles.

A seed particle is defined as a particle too large to be carried out with the exhaust airflow through the granulator, and large enough to prevent being agglomerated with other particles, and smaller than the desired product size.

In a conventional fluid bed granulation process the size distribution of the produced granules, has been controlled by recycling a certain fraction of undersized granules and crushed oversized granules to the granulator. This is easing the operation and the flexibility of the process, making it possible to handle various systems and granulometry, and still be able to control the conditions in the fluid bed, i.e. the liquid phase and the crystallisation evaporation rate. The fact that a fluidized bed granulator operates as a total mixed reactor has further supported the robust design and operational philosophy.

An excessive recycle stream, 0.5 to 2 times the product flow, carrying an excess of seed granules and mass flow, limits the influence of and sensitivity to other operating parameters. This has limited the interest for developing classifying granulators. Fluid bed granulation processes are sensitive to the number of seed particles produced, as agglomeration is undesired and should be avoided from a product quality and operating stability point of view. Agglomeration creates particles with lower crushing strength and it is difficult to use agglomeration to control the particle balance without increasing the recycle ratio to 3-7. A robust design with an excess recycle stream as an important control parameter, has been preferred by the industry. A low recycle flow is only possible when the numbers of seed particles are produced in a precise and stable number.

A classifying fluid bed granulator is defined as a granulator being able to discharge the product being the largest granule fraction contained in the bed. The product continuously has a granule size which is larger than the granules in the granulator. The efficiency of the classification depends on the methods applied for classification and the size differences handled by the bed. A classifying granulator will in a dynamic process give a shorter retention time for the desired product fraction of large granules, thus giving a longer retention time for the smaller granules, enabling them to grow more before reaching the product size and be discharged. A classifying granulator will also be able to perform as an ideal plug flow reactor, given a feed of uniform seed material. Screening and recycling of the granules in conventional fluid bed granulators, is always done outside the bed as for instance described in US Patent 4219589.

Building mechanical screening and crushing into or close to the fluid bed granulator is described in DE 3248504-C2 but has been seen as not advantageous from an operational point of view.

However, US Patent 4790487 describes a continuous granulator where screening and recycling is done in an adjacent unit being a combined screw conveyor and fluid bed. The patent describes an apparatus comprising a granulator body for continuously processing powdered materials into granules and a screw conveyor for discharging the produced granules from the granulator body, the screw conveyor including means for pneumatically classifying the produced granules while they are being conveyed. The patented principle will only be able to separate and recycle the dust or fine particles from the discharge flow. The classification efficiency in the method is based on the difference in escape velocity between the large onsize granules and the dust fraction, and will not be able to separate 1-2 mm particles out of a mass containing 1-5 mm particles. The bubble formation and slugging will create a flow of particles of all sizes between 1-5 mm back to the granulator.

Internal segregation effects in fluidized, spouted and moving beds have been described in several publications. The effects of air velocity and bubble breaking constructions inside the bed have given documented effects achieving a particle size difference between top and bottom in a single bed compartment. In "Powder Technology 98" (1998) 273-278, the effect of horizontal baffles are described and documented.

The bed design with the internal baffles results in a single chamber high bed with a subsequent high pressure drop. The total bed movement is reduced by both the baffles and the geometry, and the bed achieves a lower capacity, because the heat and mass transfer requires turbulence and particle movement.

Another disadvantage, making these principles less useful, is the lack of horizontal classification. With a vertical classification effect only, size and shape of the granulator is limited in area to bed height ratio, and is therefore tested in a single chamber only. Horizontal baffles placed in the single granulator chamber, as described in WO 97/02887, is also seen as a practical disadvantage, as it gives less freedom to install spraying nozzles.

A significant disadvantage with a conventional but robust fluid bed process, is the high investment costs in screens, crushers, dissolving units, dryers, coolers, intermediate storage and solid material transportation inside the plant. This requires large buildings and expensive steel constructions to enable an operable layout. Each mechanical and electrical item requires design, engineering, commissioning, spare parts, monitoring, maintenance, cleaning and attention from operators. In corrosive environment given by salts and humidity, the quality of materials increases the investment cost further. The number of mechanical items increases the failure rate and risk of expensive down time.

Furthermore, operation of these granulation plants requires frequent stops for maintenance of mechanical and electrical equipment and cleaning of process equipment. Recovery of washing water and extra space inside the plants for maintenance activities, further increases the cost for constructing and operating such plants. Reducing the recycle flow by optimizing the seed production and controlling the crystallization and solidification process has given some competitive advantages for the best processes.

Thermodynamically it is possible to design a fluid bed process with no recycling of cooled or heated granules outside the fluid bed. An optimum heat balance over a fluid bed granulator can be achieved by changing air temperature or air flow. A relatively large air flow is anyway required for the fluidization itself. The heat balance can alternatively be solved by internal cooling or heating in the fluid bed itself.

However, to operate a fluid bed granulation process without recycling material requires a control of the granule growth in a different way than in conventional beds mentioned above. Granule growth and product granulometry in conventional beds are a function of size distribution of feed or crushed recycled material, the feed to melt ratio, and classifying effects in the fluid bed or granulator. Conventional beds have low classifying efficiency, operating almost like a total mixed flow reactor. The product from a total mixed reactor will consist of a mix of fresh undersized feed and matured larger particles. Even with an ideal plug flow reactor the product is largely depending on the size distribution of the feed or recycled material.

It is an object of the present invention to provide a method and a device which are able to process a solution, melt, suspension, slurry, emulsion or solids into granules of a classified size.

It is another object of the present invention to provide a method and a device which are able to process a solution, melt, suspension, slurry, emulsions or solids into granules in one stage, in one fluidized bed, without screening, recycling, crushing and dissolving.

Furthermore, it is another object of the present invention to provide a method and a device mentioned above which reduce the investment cost for a fluid bed granulator unit, and increase the capacity when introduced in existing plants.

The inventors have developed a method and a device for fluid bed granulation which are able to process a melt, solution, solid, emulsion, slurry or suspension into granules of a narrow size distribution.

The classifying fluid bed granulator according to the present invention, comprises a granulation chamber including a fluidizing air chamber 7 with a bed floor 10, a ceiling 3c, an end wall 3d, a feed inlet 5, a seed inlet 6, an outlet 4 defined by walls 3a,3b for air, an outlet 9 for produced granules. The granulation chamber is divided into an agglomeration and seed control section 1 and a granulation and classification section 2 where said section 2 consists of one or more consecutive compartments having an asymmetric design.

The method according to the present invention, for fluid bed granulation of a feed being a solution, slurry, melt, emulsion, suspension or solids into granules of a desired classified size, comprises that inlet seed particles to be granulated with the feed are given a controlled size in an agglomeration and seed section ahead of a granulation and classification section and that the classification of the granules is performed in asymmetric compartments in the granulation and classification section.

The granulator consists of one or preferably several spray and particle growth compartments with an asymmetric design and with tilted separation baffles which result in classification of particles in each compartment and transport of large particles towards the outlet and small particles towards the inlet of the bed.

The asymmetric design, obtained by tilting the separation baffles and sloping the bed floor, creates differentiations in fluidization air flow in various parts of the bed and within each compartment.

The classifying fluid bed granulator unit itself, according to the present invention, is performing internally what the screens and recycle loop are doing in a conventional granulation loop. In the classifying fluid bed the granules which are smaller than the desired product are given a longer residence time inside the bed, until they have grown to the desired product size. Thus, there will be no small particles which have to be recirculated. In a conventional bed the smallest granules have to be recycled back to the bed to get a longer retention time. In the classifying fluid bed the large particles will have a short residence time. The conventional bed does not give large particles shorter residence time, and small longer residence time. Thus, there will be a higher fraction of too large particles produced in the bed. This together with the granule growth balance requires a continuos crushing of oversize particles.

In the classifying fluid bed a controlled crushing can however be introduced in the form of a rotor with variable speed placed in the seed and agglomeration control compartment. This will be required to produce enough seed material for the granulometry balance.

The dependence on the feed seed granulometry is reduced. From the granulometry aspect it is basically the number of seed particles and enlargement factor which determine the capacity.

The effect of segregation in a sliding mass of inhomogeneous particles is known but not utilised in fluid bed granulator design. The segregation in a vibrated mass called percolation, where dust and smaller particles fall down between the larger granules, is also not utilized. This effect is more pronounced when movement is low, and will in a fluid bed be prevented or reversed by the air flow.

Segregation in a sliding or moving mass is utilised in pan granulation and in some drum granulators, but the mass and energy balance for these granulation processes normally requires a well defined and large amount of temperature controlled recycle material.

Important features of the design is the asymmetry provided by the tilting baffle plates and/or the sloping of the floor. The higher fluidization velocity towards the outlet of the bed, combined with the sloped ceiling towards the outlet, gives a circular flow pattern both in the total bed and between the tilted baffles. The higher air velocity and kinetic energy input on one side gives a higher bed level due to the lower density. This results in an effect where small particles on the top of the bed are floating back to the agglomeration and seed control section, and the largest particles will float along the floor due to the circular flow between the plates or inside each chamber, and the overall circulating flow.

Between compartments and over each plate, a stagewise classification is obtained by creating a high velocity bubble zone for the coarse material, and a low velocity zone for the smaller particles. With an internal horizontal segregation in each compartment, a random exchange of particles between compartments will give an overall classification from compartment to compartment. In addition will the overall circular bed movement secure a movement of larger particles towards the outlet along the floor, and of fine particles back towards the inlet at the top of the bed.

The geometry of the baffles and shape of the classifying area must be tailored to fit the actual granulation system. The baffles are providing a multistage classification system, with a certain efficiency over each stage. The baffles divides the granulator into a series of steps resembling a multistage reactor. The achieved effect is resembling a plug flow and combined with the controlled recycle of fines over the top of the plates gives a multiple stage classifying effect like for a distillation column. The size distribution of the product leaving the bed is clearly narrower than the total size distribution of the product contained in the granulator.

The air flow direction at the upper portion of the fluidized area in the classifying area, is transporting the smaller particles towards the growth area of the bed, where they function as seed material. The overall air flow above the top of the bed level is together with the mechanical design wind screening the granules and sending the smallest to the granulation zone and allowing the large particles to leave as product.

Provided a uniform size distribution of the feed to the granulator, the retention time distribution will also be narrowed, with a design according to the present invention.

There are various way of providing seeding to a granulator without crushing a part of the product. A pre-agglomeration or a small prilling tower has been proposed, as well as installing a grinder or crusher inside the bed. A rotor with a variable speed can be utilised to provide seed material and control the product particle size.

The invention will be further explained and envisaged in the following figures and example.

Figure 1 shows a side view in a reduced scale of one design of the classifying fluid bed granulator according to the present invention with sloped bed floor and tilted baffle plates.

Figure 2 shows a side view in a reduced scale of an alternative design of the classifying fluid bed granulator according to the present invention with horizontal bed floor, tilted baffle plates and a fluidized air chamber divided into compartments.

Figure 3 illustrates the classification effects in the classifying fluid bed granulator according to the present invention.

Figure 4 shows a geometrical sketch of how V-shaped baffles can be installed in the granulator according to the present invention.

Figure 5 illustrates how V-shaped baffle plates will further enhance the effect of the baffles.

Figure 6 shows a side view of a pilot unit of the granulator according to the present invention.

Figure 7 illustrates the classification efficiency calculation.

Figure 8 illustrates the results of the dynamic tests.

Figure 9 illustrates the classification efficiency calculation.

Figs. 1 and 2 show a fluid bed granulator which comprises a typical agglomeration and seed control section 1, a granulation and classification section 2, an air pressure chamber 7 and a horizontal uphill sloped bed floor 10. Section 2 contains tilted baffle plates 12. Furthermore, the granulator consists of an inlet 5 for feeding the melt, solution, emulsion, slurry, solids or suspension into section 1, an inlet for seed material 6, an outlet 4 defined by walls 3a,3b for discharging air, a ceiling 3c, an end wall 3d and an outlet 9 for discharging produced granules of desired size.

In the agglomeration and seed control section 1, which may consist of one or more consecutive compartments, the melt, suspension, slurry, solids or solution is sprayed onto the seed particles where it solidifies creating agglomeration or layering. Necessary seed production can be done outside or inside the fluid bed by means of physical crushing.

The compartment(s) in section 1 may perform as a turbulent total mixed reactor(s), which is necessary to achieve high capacity of melt injection without creating excess agglomeration and lump formation. Low air velocity gives more agglomeration, is reducing the dust formation, and is reducing the carryover of dust with air exiting the bed 4. The total load and air velocity in section 1 may in this way be used to control the seed production and granulometry of the whole bed. The spraying technique may be with two-phase or one phase nozzles. Nozzle direction may also vary depending on the individual properties between melt or solution systems. The transport of the largest particles from section 1 to section 2 takes place along the floor 10, and is caused by the rotational driving force in the total bed given by the slope of the floor, the difference in fluidization air rate, and/or by directional nozzles in the bed floor. Some large particles are also carried over at the top of the bed where the bubble breaking is randomly sending particles in all directions. The larger particles are less affected by the horizontal air flow on the top of the bed, and will easier move to the compartment closer to the outlet, than the smaller particles which will be taken by the horizontal air flow back into the existing compartment or to the compartment closer to the inlet.

The air velocities in the granulation and classification section 2 may be higher, than for the agglomeration and seed control section 1, and the air velocity should also be higher for each compartment towards the outlet 9, as a requirement for fluidizing the increased particle size, but also as an important factor for the overall classification. A higher fluidization air velocity gives a higher air pressure in the bed and higher level in the bed. The horizontal gradient in air and bed pressure gives an average horizontal air flow component in the bed, which gives a horizontal segregation. Smaller particles are blown back towards the agglomeraon and seed control section 1. The air chamber 7 may comprise consecutive compartments. One way of achieving a higher fluidization air velocity towards the outlet is to reduce the pressure drop over the bed floor 10 towards the outlet, or to increase the pressure in the consecutive air compartments towards the outlet. The pressure drop can be adjusted by means of the size or number of openings in the perforated bed floor.

The bed height will also affect the air velocity. A higher bed level gives a higher pressure drop and lower air flow for that area. This can be achieved by the slope of the bed floor 10 as shown in Figs. 1 and 2. A higher air flow in chamber(s) in the granulation section 2 towards the outlet 9 gives a higher average level of material in the these sections and compartments, and there will be a transport of smaller particles from the upper zone 3 in these sections, back to the agglomeration and seed control section 1. This effect is further enhanced by the free airflow zone 3 towards the air outlet 4.

Cooling, if required, is provided by a low temperature fluidization air, and/or with internal cooling plates or tubes submerged horizontally or vertically the fluidized material in the bed.

In the granulation and classification section 2, it is important to break or control the bubbles which are formed in a fluidized high density bed. These bubbles transport coarse material from the bottom to the top of the bed. With the horizontal asymmetry in both air velocity and geometry, the bubbles are as shown in Fig. 3 moving horizontally towards the tilted baffle or compartment wall where they change shape 11, leaving the coarse material as it raises along the baffle and breaks through the surface of the material contained in the bed. At the break-through of the bubble, the ejection of material gives a transport of fines backwards and coarse forward in the bed.

On the other side of the baffle, smaller particles will be increasingly concentrated in a downward movement. The lack of turbulence and lower air velocity favours collection of small particles. The smaller particles will be moving downwards, under the baffle and into the next chamber or section. The distance from the lower end of the baffle plate to the bed floor, should be tuned to achieve a stable circular movement between the plates, and sufficient transport between the chambers. The angle and shape of the baffle plates are important to achieve the right flow pattern. The transport of particles on both sides of the baffle plate can further be improved by V-shaping the plate, making the transfer between chambers even better, as shown in Figs. 4 and 5.

The raising bubbles of coarse material in zone 3 is transporting coarse material up and over to the downward fines zone in 2 in the next compartment. In the same way, small particles in 2 will be transferred back to zone 3 in the previous compartment. At the top and bottom of the bed, below and above the baffles, a random movement pattern will secure exchange between the compartment.

Example:

This example shows test results achieved with a classifying fluid bed granulator unit as shown in Fig. 6. The unit was operated with the following parameters:

Material:	Urea granules with a bulk density of 1000 kg/m^3
Air velocity:	1.1-1.4 m/s
Air temperature:	Ambient, 20-22° Celsius
Bed filling:	32.5-37 kg
Bed slope, α:	6°
Baffle slope β:	15°

Typical size distribution of the material in the test bed is shown in Table 1:

Table 1 Typical size distribution in test bed

Above 6 mm	1%
Between 6.3 - 4.5 mm	9%
Between 4.5 - 3.5 mm	28%
Between 3.5 - 2.5 mm	49%
Between 2.5 - 1.6 mm	11%
Between 1.6 - 1.0 mm	2%
Between 1.0 - 0.0 mm	0%

The tests have been performed with the aim of finding the most effective design, and a classification efficiency measure has been introduced. The measure is calculating how the D50 of the outlet product is compared to the D50 for the whole content in the bed. If the D50 of the outlet is equal to the total bed D50, the classification efficiency is 0%, which means no effect compared to a total mixed bed. If the D50 of outlet is equal to D90 of the whole bed, the classification efficiency is 80%. The D50 is the granule diameter which split the mass into 50% of the granules smaller than this diameter and subsequently 50% of the granules larger. The D90 is in the same way the diameter which split the mass into 90% of the granules smaller than this diameter, and subsequently 10% of the granule mass larger that this diameter.

Fig. 7 is illustrating the classification efficiency calculation.

The bed efficiency has been tested both in dynamic and static situations, static meaning that the bed has been filled, and operated without any discharge or feed of material. Sampling of the outlet has been done only to check that steady state has been achieved.

The dynamic tests were simulated by taking out product at the outlet and re-feeding it to the inlet. The load has been calculated as retention time. Simulated retention time of 10 minutes has been used in the dynamic testing.

Figs 8 and 9 are illustrating the results of the tests. Fig. 8 is showing how the size distribution curve of the outlet is changing compared to the total content of the bed. Fig. 9 is showing the same for the accumulated size distribution curve.

Table 2 is showing a representative extract of the classification efficiency results. The best results are achieved with three baffles tilted 15 degrees, and a bed sloped 6 to10 degrees. Positive results are although achieved with several features as indicated in the table.

Table 2 Test results

Test No.	Number of Baffles	Slope of Baffles in degrees	Slope of Bed in degrees	Ceiling position	Load as retention time	Classification efficiency
0	One	As for Bed	0	No ceiling	No load	0%
5	"	"	0	Ceiling down	No load	13%
3	"	"	4	Ceiling down	30 min.	36%
4	"	"	4	Ceiling down	10 min.	48%
5	"	"	4	Ceiling down	No load	50%
6	"	"	6	Ceiling down	10 min.	54%
7	"	"	10	Ceiling down	10 min.	45%
8	Three	4	4	Ceiling down	10 min.	72%
9	"	15	4	No ceiling	10 min.	82%
10	"	15	4	Ceiling down	10 min.	64%

Test number 10 was done with a higher bed level, which was creating a change in fluidization conditions towards the outlet of the bed due to restrictions.

The present invention will open for granulation without screening and recycling granules outside the bed, given only a suitable seeding process or a feed of seed material.

As an example the fluid bed will be perfect for fattening or post granulation of smallprilled particles of 1-2 mm to larger granules of 3-7 mm.

CLAIMS:

1. A classifying fluid bed granulator, comprising a granulation chamber including a fluidizing air chamber (7) with a bed floor (10), a ceiling (3c), an end wall (3d), a feed inlet (5), a seed inlet (6), an outlet (4) defined by walls (3a,3b) for air, an outlet (9) for produced granules, where the granulation chamber is divided into an agglomeration and seed control section (1) and a granulation and classification section (2) where said section (2) consists of one or more consecutive compartments having an asymmetric design.

2. A classifying fluid bed granulator according to claim 1,
c h a r a c t e r i s e d i n t h a t
the asymmetric design is provided by baffle plates (12) in section (2) forming an angle with the horizontal plane.

3. A classifying fluid bed granulator according to claim 1,
c h a r a c t e r i s e d i n t h a t
the bed floor (10) forms an angle with the horizontal plane, sloping uphill towards the outlet (9) of the produced granules.

4. A classifying fluid bed granulator according to claim 1,
c h a r a c t e r i s e d i n t h a t
the asymmetric design is provided by baffle plates (12) forming an angle with the horizontal plane and the bed floor (10) forms an angle with the horizontal plane, sloping uphill towards the outlet (9) of the produced granules.

5. A classifying fluid bed granulator according to claim 1,
c h a r a c t e r i s e d i n t h a t
the agglomeration and seed control section (1) is divided into at least one compartment.

6. A classifying fluid bed granulator according to claim 1,
c h a r a c t e r i s e d i n t h a t
the air chamber (7) is divided into two or more air compartments.

7. A classifying fluid bed granulator according to claim 1,
c h a r a c t e r i s e d i n t h a t
the bed floor (10) is provided for giving different amount of fluidizing air to sections (1) and (2) by perforations having different sizes.

8. A classifying fluid bed granulator according to claim 2,
c h a r a c t e r i s e d i n t h a t
the baffle plates are V-shaped.

9. A classifying fluid bed granulator according to claim 1,
c h a r a c t e r i s e d i n t h a t
the wall (3d), and ceiling (3c) close to the outlet (9) are sloping inwardly.

10. A method for fluid bed granulation of a feed being a solution, slurry, melt, emulsion, suspension or solids into granules of a desired classified size, comprising that inlet seed particles to be granulated with the feed are given a controlled size in an agglomeration and seed section ahead of a granulation and classification section and that the classification of the granules is performed in asymmetric compartments in the granulation and classification section.

11. A method for fluid bed granulation according to claim 10, characterised in that tilted baffle plates are utilized to separate the compartments resulting in classification of granules in each compartment and that the largest particles are transported from the agglomeration and seed control section to the granulation and classification section along the bed floor and the small particles are transported towards the inlet of the bed.

12. A method for fluid bed granulation according to claim 7, characterised in that a rotational driving force in the fluidized bed is created by sloping the bed floor uphill towards the outlet of the produced granules and/or sloping the end wall and the ceiling, providing a difference in fluidization air velocity for the various compartments and/or by directional nozzles in the bed floor.

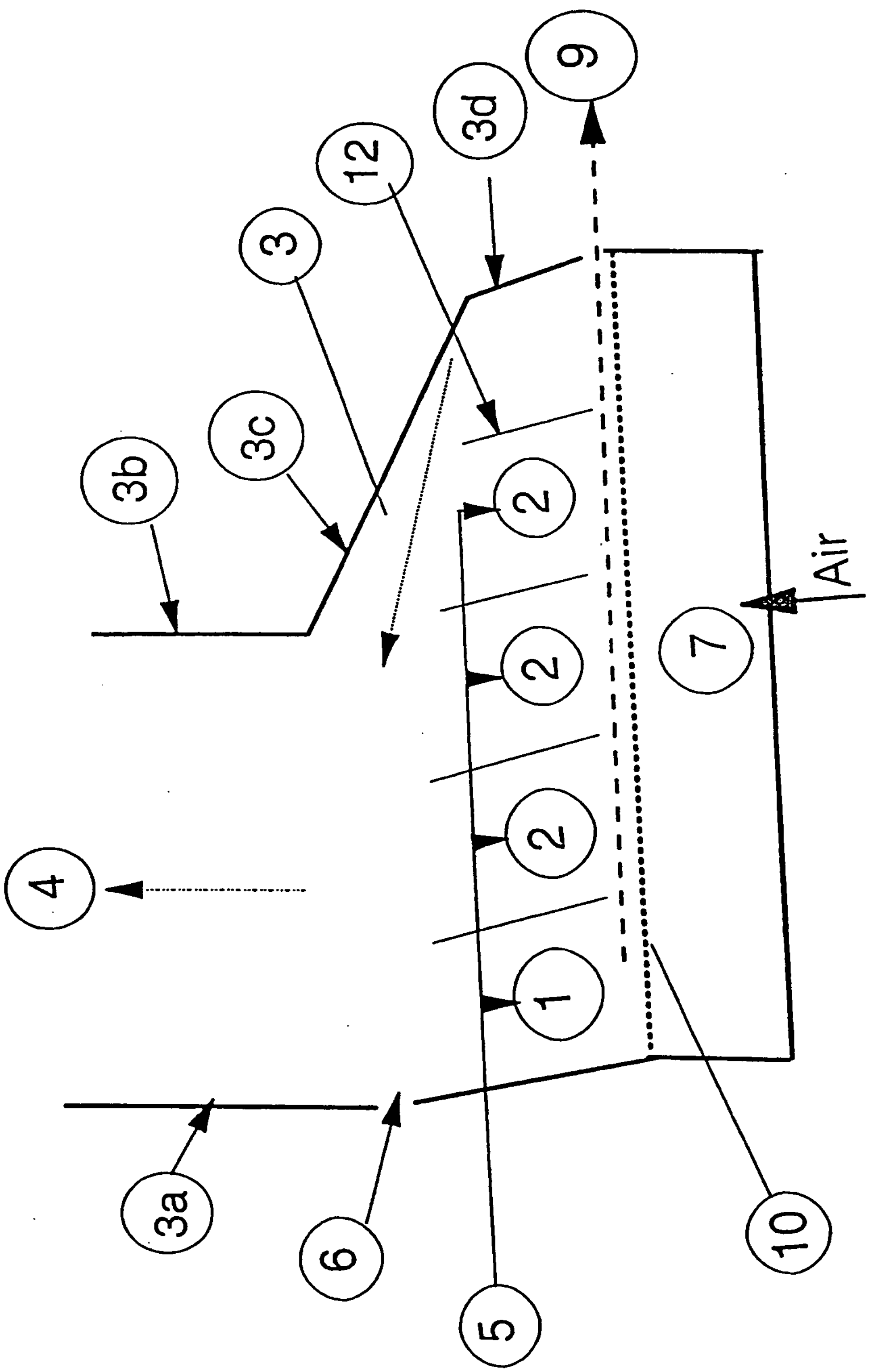


Figure 1. Classifying Fluid Bed, Open Design, Side View

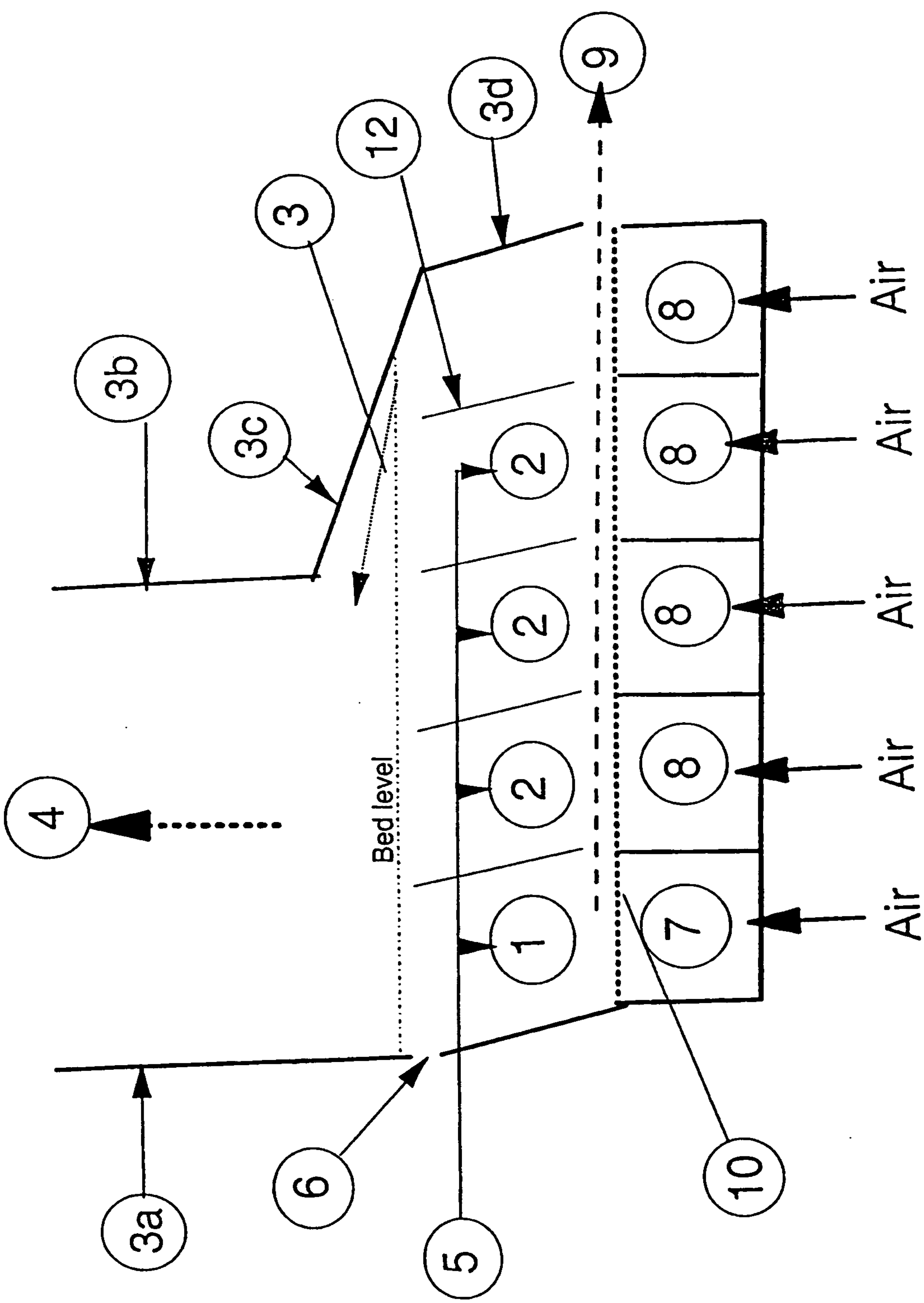
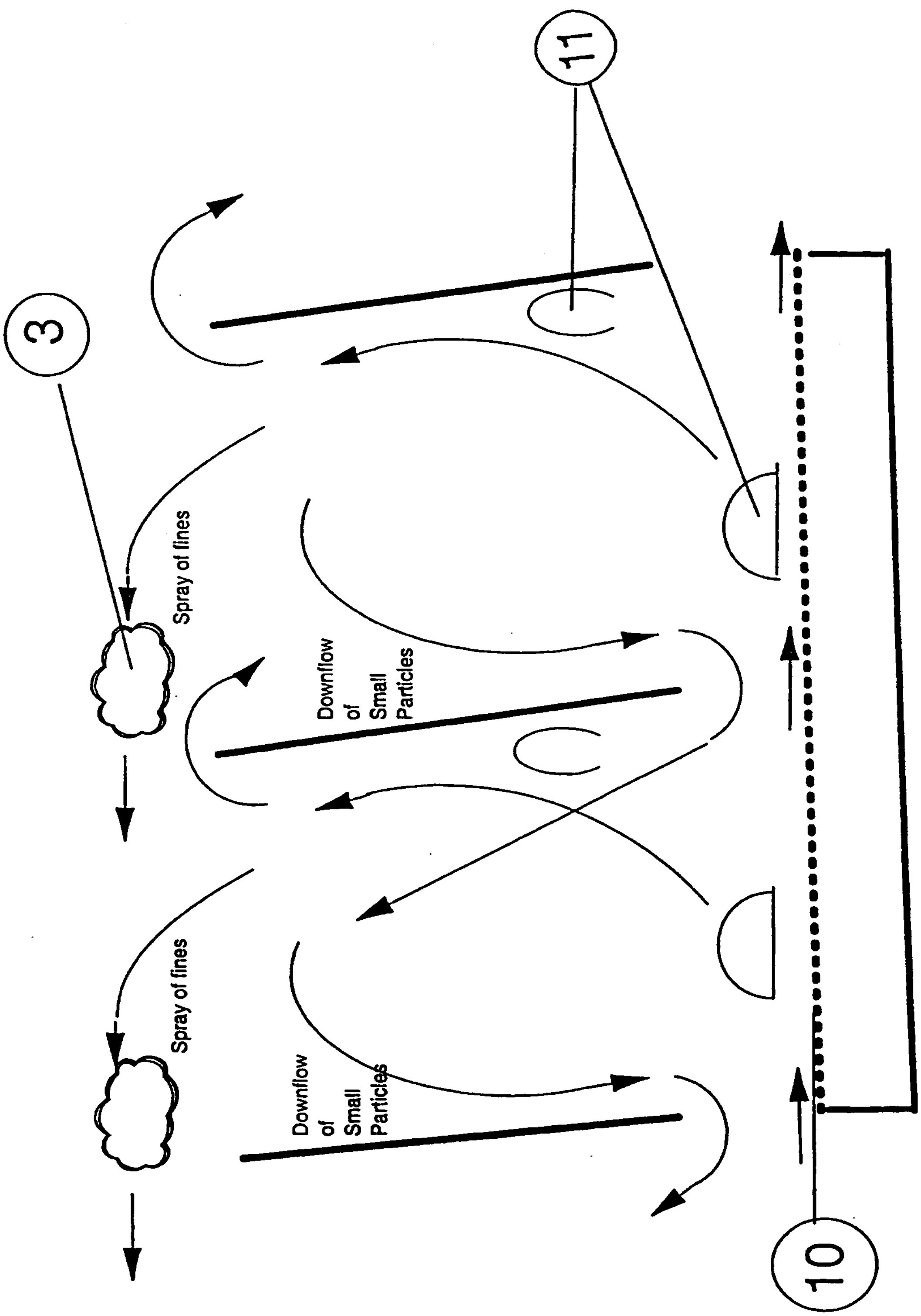


Figure 2. Classifying Fluid Bed, Camber Design, Side View

Figure 3. Classifying Fluid Bed detail of classifying effects



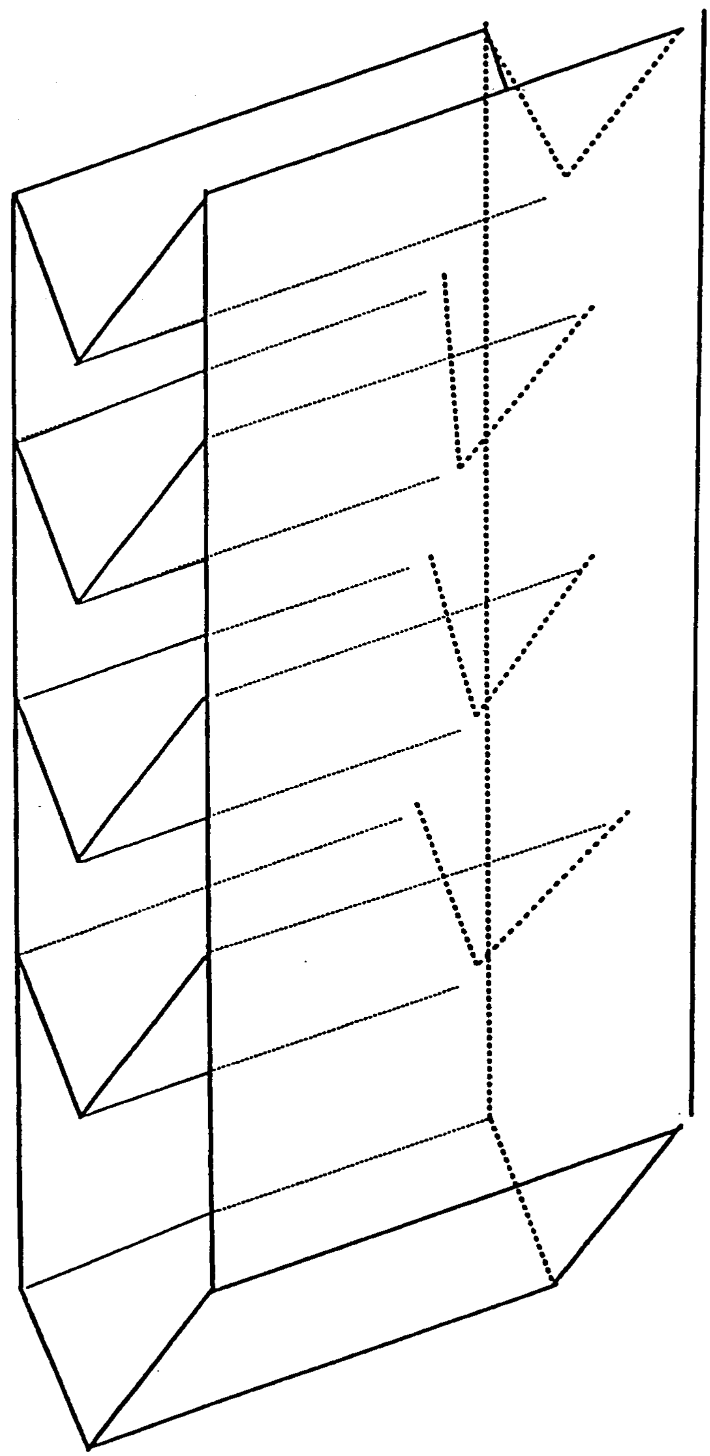
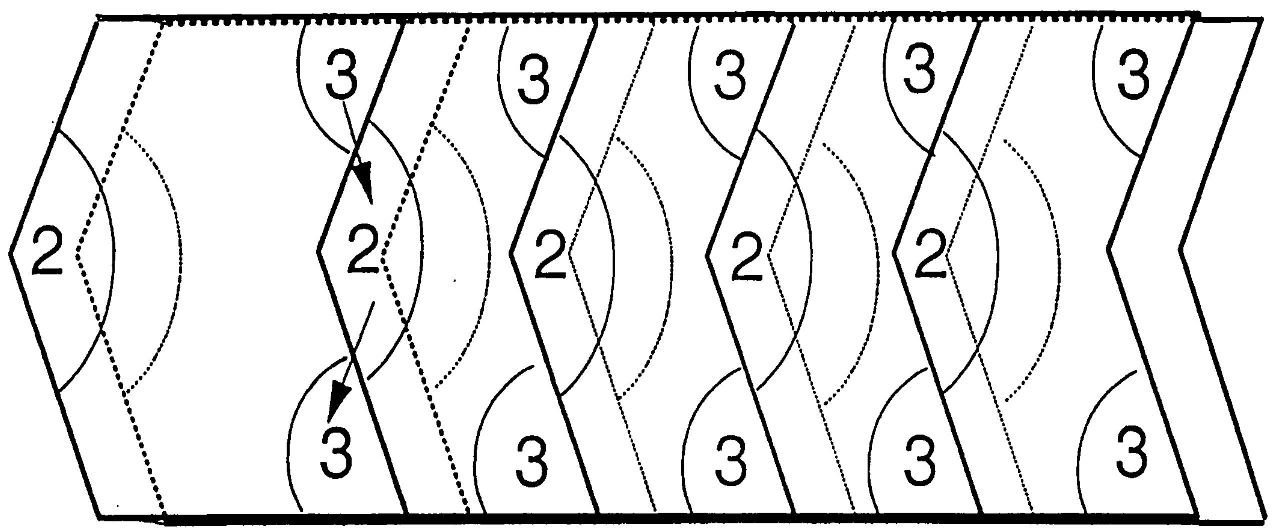


Figure 4. Classifying Fluid Bed, Typical geometry of V-shaped baffles

Figure 5. Classifying Fluid Bed with V-shaped baffles, Top View

2) Areas marked with 2, indicates where small particles are moving downwards
3) Areas marked with 3, indicate where larger particles are moving upwards in a turbulent bubbeling area.



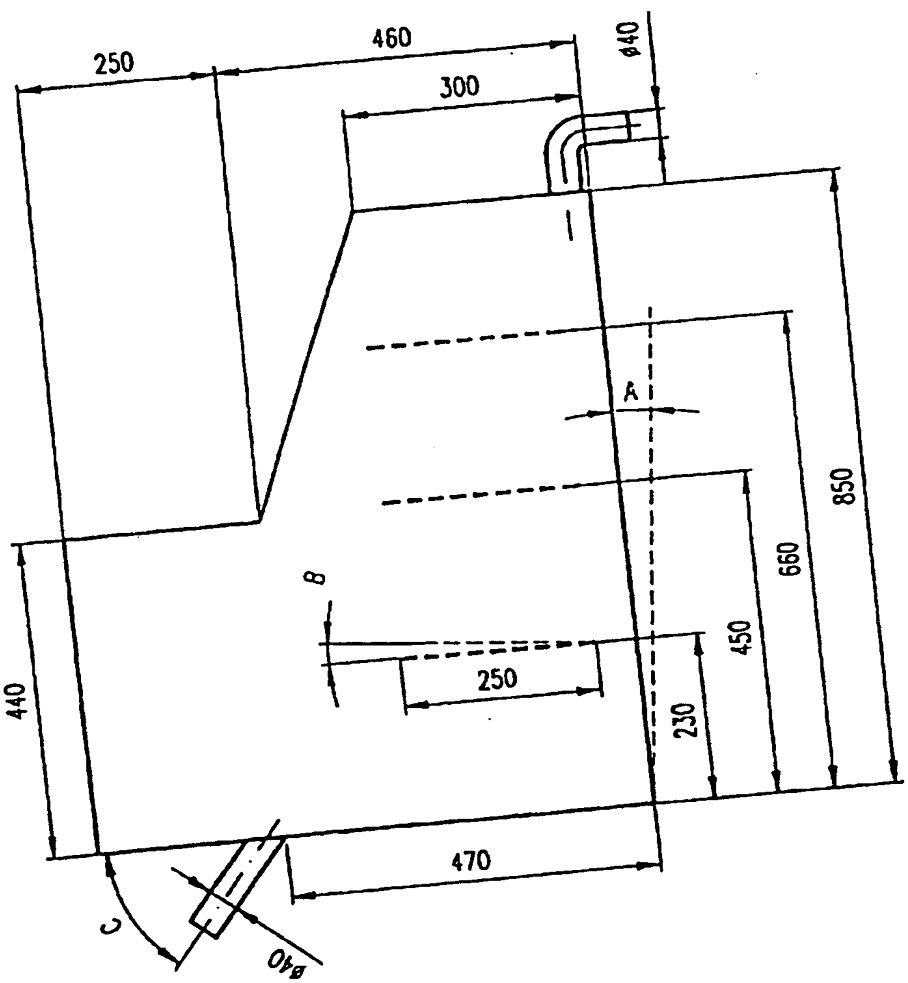


Figure 6 is showing the side view of the Fluid Bed pilot plant

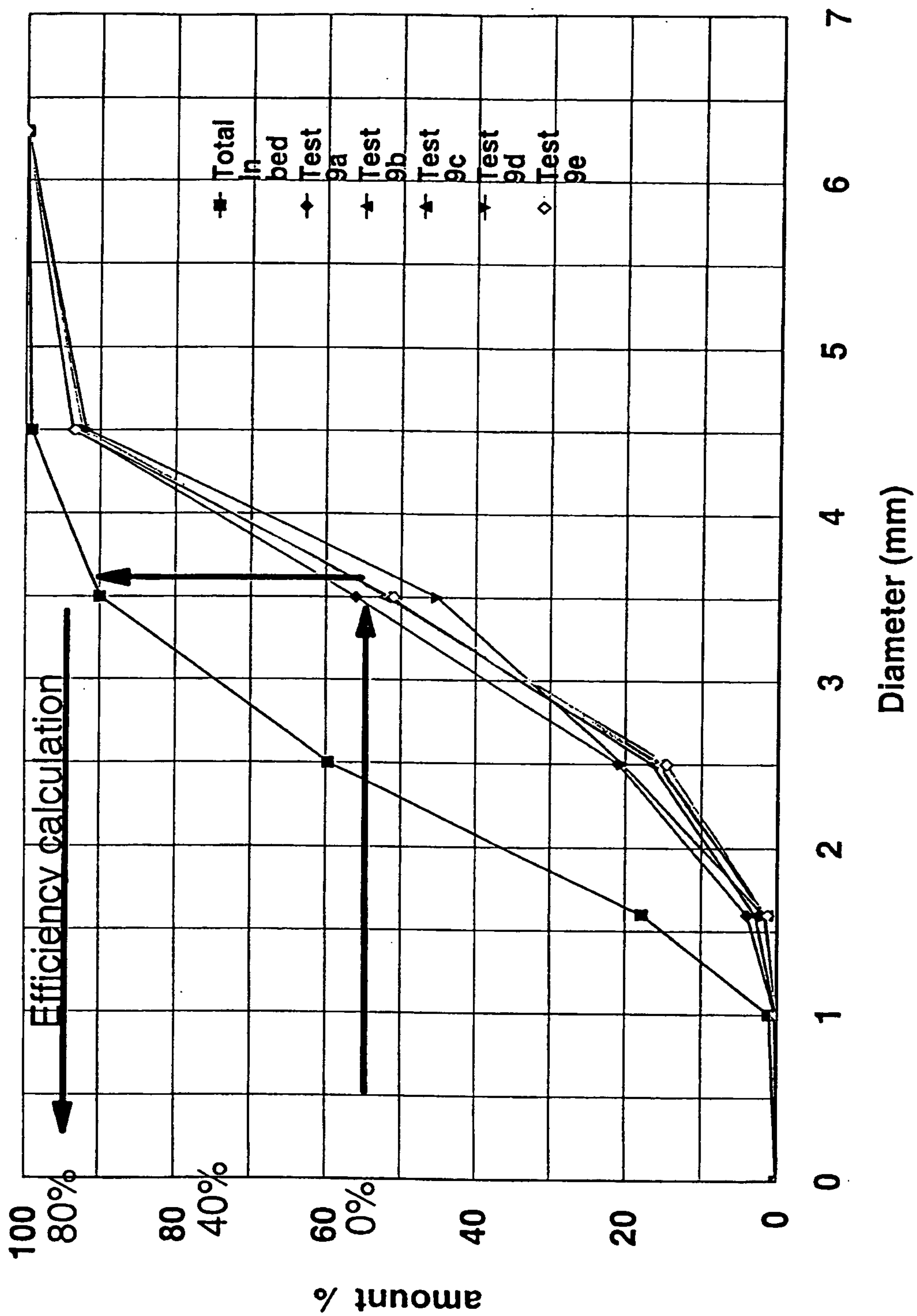


Figure 7. Calculation of Classification efficiency

Figure 8. Results dynamic test

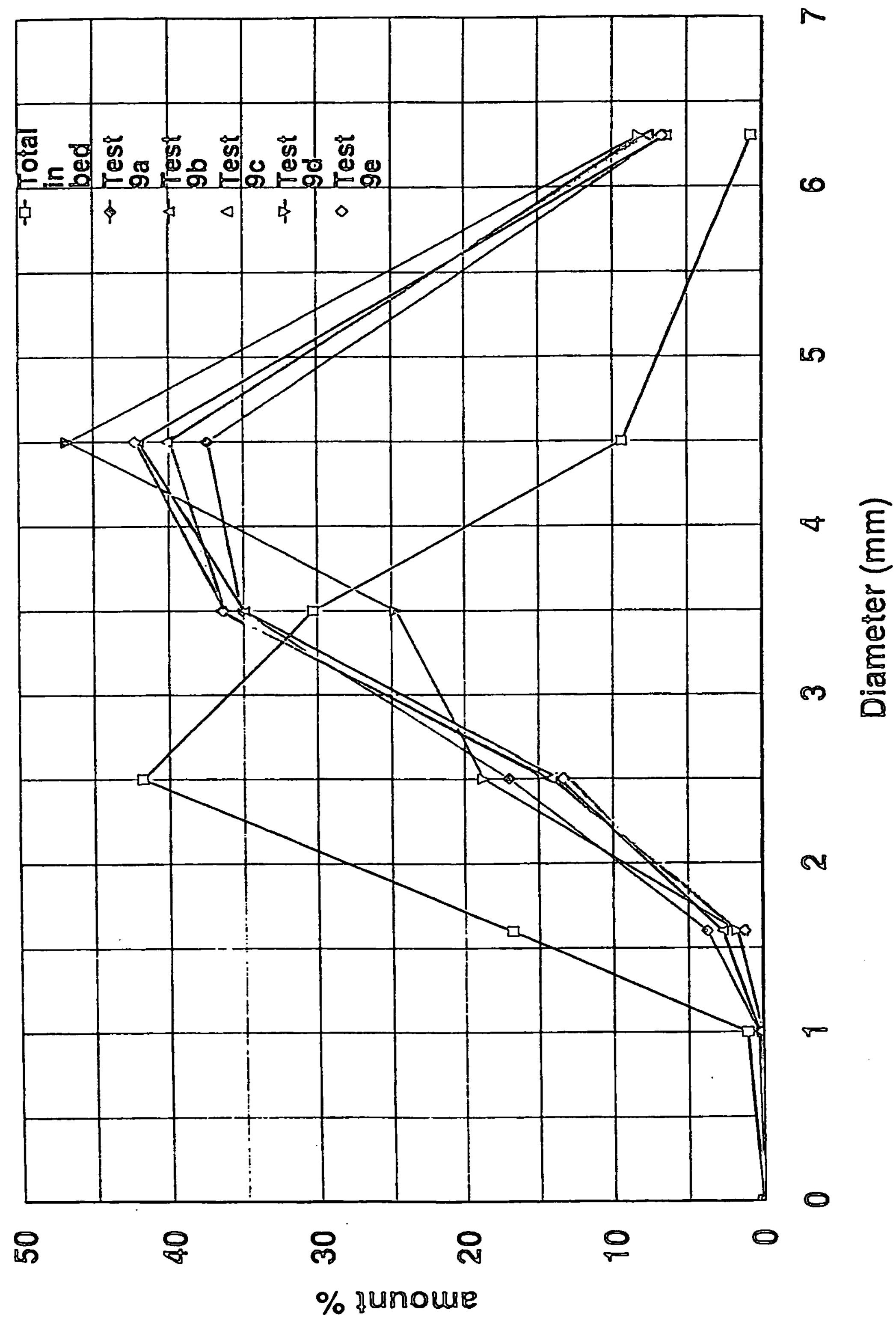
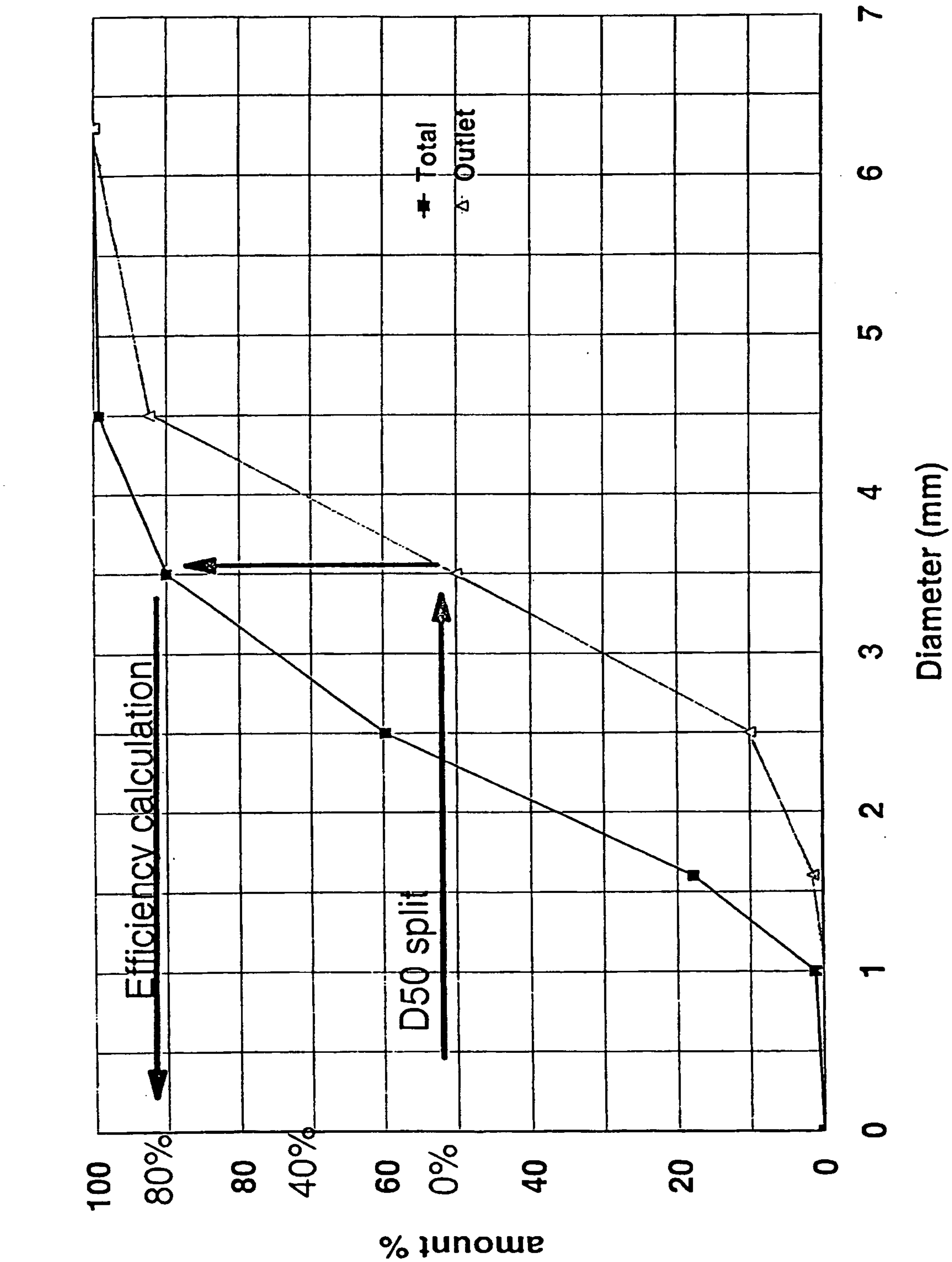


Figure 9. Calculation of Classification efficiency



INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 00/00410

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B01J 2/16, B01J 8/24, B01J 8/34
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B01J, F23C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A		3,4,7,9,12
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X	WO 0045959 A1 (THE UNIVERSITY OF NEWCASTLE RESEARCH ASSOCIATES LIMITED), 10 August 2000 (10.08.00)	1,2,5,10,11
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A	GB 1132925 A (ROGER MAX KALTENBACH), 6 November 1968 (06.11.68), figures 1,2	1-9,10-12
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 April 2001	04-04-2001
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Nils Engnell/MP Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

25/02/01

International application No.
PCT/NO 00/00410

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